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Aircrew Performance

Research Memorandum 75-4

NIGHT TRAINING BY SIMULATING THE NIGHT VISUAL ENVIRONMENT DURING THE DAY

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NIGHT TRAINING BY SIMULATING THE NIGHT VISUAL ENVIRONMENT DURING THE DAY

ABSTRACT

The purpose of this research memorandum is to (1) document ARI progress on research to develop a night training technique by simulating a night visual environment during the daytime, (2) report results of preliminary field tests, and (3) state plans for future research.

It would be advantageous to the Army to be able to conduct certain night operations and training during daylight conditions. Aviation is an area where this advantage would be critical. Hovering or landing a helicopter is a complex perceptual-motor task under the best of conditions; at night, or under other conditions of limited visibility, the difficulty increases enormously. Without daylight and the normal perceptual cues, less experienced pilots have a strong tendency to drift out of position, especially to one side or to the rear, making these maneuvers hazardous at night.

The author hypothesized that it might be possible to simulate night conditions by means of light-attenuating goggles and to conduct training or evaluation flights in which one pilot would use these goggles while an instructor/safety pilot (without goggles) sat by dual controls to take corrective action when necessary for safety. The instructor pilot could also better observe the performance of the student pilot, make more extensive evaluations, and provide more feedback than under actual night conditions.

ABSTRACT

There are also other military situations where a simulated night visual environment would be advantageous, such as armored vehicle operations, motor vehicle driving, or infantry squad exercises.

PREVIOUS WORK

The U.S. Armed Forces have used goggles extensively, both to provide eye protection and to improve human performance (Farnsworth, 1951). Perhaps the best known use of goggles to improve performance was the red goggles that were introduced early in World War II to promote dark adaptation (Ives and Shilling, 1941). Another type, slightly similar to those used in the present study, was a dual density goggle with a very dense strip near the top, which was used in World War II to permit aviators to search for enemy aircraft near the sun (Pison, 1944).

Some work has been done on the specific topic of simulation of night conditions during the daylight for training or evaluation purposes, but since most attempts have been relatively unsuccessful, this work has largely gone unpublished. In the late 1940's in Britain a similar goal was pursued with fixed-wing aircraft and separate bubble canopies for each pilot. The bubble of the pilot being tested was twin-walled, and an opaquing fluid circulated between the two walls. Engineering problems were difficult; because the amount of fluid was not uniform in all areas, uneven attenuation of light resulted. (Lazo, 1974).

Various combinations of blue and amber filters as well as polaroid materials have also been used in aircraft training. With both of these techniques, one filter must be applied to the windscreen and one inserted in the goggles of the student pilot. These techniques were capable of totally occluding the area outside the cockpit for the student pilot and giving the instructor vision outside the cockpit. However, night conditions were not simulated effectively, and with the introduction of simulators for instrument training, work with these materials was largely discontinued. Neutral density filters, somewhat similar to those used in the present study but at much lighter densities, have been used in Air Force research to simulate twilight and dusk conditions but not to simulate night (Porterfield and Self, 1971).

In the infantry, attempts were made to conduct night training with dark goggles during the day, in tests at Fort Benning, Georgia, in 1959 and at Fort Sheridan, Illinois, in 1969 (Greer, 1974). At Fort Benning, the feasibility of the concept was investigated but the project was cancelled before extensive testing took place.

More extensive investigations were made in 1969 in tests sponsored by the Training Aids Section of Fifth Army Headquarters at Fort Sheridan. Colonel Howard Greer conducted the preliminary studies, using exposed x-ray film as a light-attenuating filter in standard military sun, wind, and dust goggles. Although photographic silver film presents problems of light scattering and is difficult to obtain in densities over 4.0 that are not totally occluding (Eastman Kodak Co., 1971), the results of these early trials were quite encouraging, and Greer sought a filter that would be superior to exposed photographic film. A plastic that used carbon particles for light attenuation was chosen.

During this research, Colonel Greer was transferred to Vietnam and replaced as project director by Lieutenant Colonel Robert Drudik. Drudik investigated the feasibility of using two lenses, one to simulate moonlight and one to simulate starlight, but tests convinced him that a single lens was sufficient. A lens with an optical density of approximately 5.5 was chosen, and 7,000 lenses were purchased for extensive field trials.

These trials were hampered by a number of problems. Fifth Army was not a test agency and therefore lacked the necessary support for the most effective field testing. Continuity of command was also lacking. No project officer was in command for more than a few months. Drudik was transferred to Vietnam shortly after the field tests were underway; within calendar year 1969, the project had four successive directors. Although these trials had some success, problems such as lens fogging from perspiration and light scatter when facing the sun led to the project's termination in August 1970. Both LTC Drudik (1974) and Colonel Greer (1974) believe that these drawbacks could have been corrected and an effective goggle developed if the project had possessed more resources and support as well as continuity of command.

Since this previous work was largely unpublished, there is little literature on simulating conditions of limited visibility through light attenuation, either by goggles or by other techniques.

ARI RESEARCH

ARI involvement in the area was begun in August 1973, although circumstances prevented serious efforts until May 1974. At this time photochromic material, which darkens on exposure to light, was examined as a means to attenuate light. This material was found to be unsuitable for aviation research because it did not attenuate light in the ultraviolet or infrared regions.

Requirements

It was decided that any light-attenuating goggles to simulate the night environment (LAGS) should have the following characteristics:

(1) a fairly large field of view

(2) a relatively neutral color attenuation

(3) freedom from optical distortion

(4) attenuation of light in the ultraviolet and infrared as well as the visible regions

(5) a light-tight seal to the face

(6) adequate simulation of night illumination levels

(7) durable lenses with anti-fog coating

Until quite recently these objectives could only be achieved using glass filter plates; however, plastics can now be used (Sherr, 1973).

In addition, it was determined that for certain applications (e.g., to read aircraft instruments) the goggles should be less dense in the lower field of view. This requires a dual density goggle.

Apparatus

Mock-up goggles were then developed to test the general feasibility of the concept. Using the frame of standard Army sun, wind, and dust goggles, Wratten No. 96 Neutral Density filters were inserted to attenuate light. Four goggles were fabricated with the characteristics described in Table 1. These fabricated goggles made possible the preliminary field testing of the dual density concept. However, they did not have sufficient durability to permit large-scale testing.

Table 1

OPTICAL DENSITY

GOGGLE	UPPER PORTION	LOWER PORTION
1	5.0	3.5
2	4.8	3.3
3	4.8	3.8
4	5.5	5.5

NOTE: Optical Density of 5.0 transmits 0.001% of incident light.

Preliminary Field Tests and Results:

Preliminary field studies were conducted on both infantry and aviation tasks. The aviation tests at Fort Rucker, Alabama, involved navigation at nap-of-the-earth (NOE) levels, a current tactic of flying at very low altitude to utilize terrain features to mask the aircraft from radar, and at higher altitudes. Testing of the LAGS for infantry use took place at Fort Ord and Hunter-Liggett, California.

<u>Piloting with LAGS</u>: Two pilots were tested in flying tasks where the pilot wore the LAGS. At the attenuation used, both pilots could hold a course and follow the directions of the copilot who was navigating. In maneuvering, 360° turns and 45° bank turns were made without difficulty. Both pilots were able to fly in formation without difficulty while wearing the LAGS. In landing the aircraft with the LAGS and in holding a stationary hover both pilots showed a pronounced tendency to drift to one side or to the rear in the initial attempts; however, these are the same difficulties

pilots report under actual night conditions. In obstacle avoidance and obstacle detection tasks, pilots could report passing aircraft at estimated distances of 500 meters. Poles could be detected at 200 feet and wires at 150 feet at slow speeds (below 40 knots) but not at higher speeds. Of the various goggles tested on these tasks, the configuration with an optical density of 5.0 in the upper portion and 3.5 in the lower was judged most effective.

Navigation with LAGS: Navigation with LAGS was more difficult than flying the aircraft. To a large extent, the ability to read maps and instruments was dependent upon whether the aircraft was flying toward or away from the sun. The light level in the aircraft was higher when flying away from the sun, and greater illumination was projected onto the instrument panel and the map. Under these conditions, the instruments and the larger features on the map were quite visible with the LAGS, and navigators felt that if they studied the map before the flight, marked checkpoints, etc., navigation would be possible with the LAGS. When the aircraft was flying into the sun, however, the instruments were in the shadow of the dashboard, and with this lower illumination they were not readable. The map also was not readable under these conditions because of the reduced illumination. Turning on the instrument lights did not make a noticeable difference. Both pilots and navigators also mentioned that when flying under actual night conditions, some ground lights such as street lights, automobile headlights, or neon signs are visible. These are not simulated by the LAGS; however, under actual combat conditions, these lights would not be present.

Infantry Tasks: Infantry tests included distance estimation, target detection, and walking over various types of terrain. It was determined that performance on these tasks did not differ significantly from actual night conditions. LAGS of a single density that simulated twilight and predawn conditions might be a valuable training aid for this critical period, which has great tactical significance. Under these conditions, illumination is not high enough for good vision with the naked eye but too high to permit the use of passive image intensifiers.

SUMMARY AND CONCLUSIONS

1. The LAGS effectively simulated actual night conditions for most aviation tasks. Piloting tasks were performed without difficulty. With the attenuation used, navigation was possible while flying away from the sun and wearing the LAGS, but not while flying into the sun.

2. Use of the LAGS in infantry training also shows promise.

3. Current mock-up versions of the LAGS need further development, including cemented lens elements or dual metallic coatings, increased ventilation, more durable lenses, and anti-fog coating.

PROJECTED DEVELOPMENT

The mock-up versions of the LAGS were fabricated to determine if there was merit in the general concept of simulating the night vision environment during the day. These preliminary tests were quite successful and further research is definitely indicated.

The mock-up version used, however, is too fragile for larger scale laboratory or field tests. A more sturdy version is needed for field testing on a large scale and for a series of perceptual tests in the laboratory.

There does not appear to be a single best way to construct a sturdy goggle that meets all the requirements. Light-absorbing filters with inorganic dyes, such as colloidal carbon imbedded in plastic, tend to scatter light and create a foggy appearance at high densities. Organic dyes do not have this drawback, but they attenuate light well only in the visible and ultraviolet ranges, transmitting a large amount of infrared. Metallic light-reflecting filters also have drawbacks, including color distortion. The various plastics suitable for lenses also present problems: A polycarbonate plastic filter with a combination of an organic dye and a metallic coating to filter the infrared is quite good, but it may be too rigid to be used in the frame of the standard military goggles. Other types of filters, plastics, and goggle frames are now being investigated. When a suitable combination, satisfying ARI requirements, is found, both field and laboratory experiments can be undertaken.

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